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MONETARY POLICY, PRICE STABILITY AND OUTPUT GAP STABILISATION

Vitor Gaspar and Frank Smets[1]

European Central Bank

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[1] The views expressed are solely our own and do not necessarily reflect those of the European Central Bank.

"The man of system (...) is often so enamoured with the supposed beauty of his own ideal plan of government, that he cannot suffer the smallest deviation from any part of it. He goes on to establish it completely in all its parts without any regard either to the great interests, or to the strong prejudices which may oppose it. He seems to imagine that he can arrange the different members of a great society with as much ease as the hand arranges the different pieces upon a chess-board. He does not consider that the pieces upon the chess-board have no other principle of motion besides which the hand impresses upon them; but that, in the great chess-board of human society, every single piece has a motion principle of its own, altogether different from what the legislature might chuse to impress upon it. If those two principles coincide and act in the same direction, the game of human society will go on easily and harmoniously, and is very likely to be happy and successful. If they are opposite or different, the game will go on miserably, and the society must be at all times in the highest degree of disorder."

Adam Smith, *The Theory of Moral Sentiments*, Liberty Fund, 1984, pp. 233-34.

1. Introduction

In this paper we examine the commonly held view (see Taylor, 1999) that monetary authorities face a meaningful trade-off between the volatility of inflation and the volatility of output around potential (the output gap). Our starting point is the recent analysis of optimal monetary policy in small-scale dynamic general equilibrium models with imperfect competition and nominal rigidities which typically take the form of staggered price setting. In the context of such a model (labelled the New Neoclassical Synthesis (NNS) model), Goodfriend and King (2001) have argued rigorously that in an environment where the central bank is fully credible in delivering price stability, monetary policy will be neutral in the sense of keeping output at its potential. Goodfriend and King interpret the difference between price and marginal cost – the mark-up – as analogous to a tax rate. This allows the applications of principles and results from the optimal taxation literature. In this context the case they make for price stability is analogous to the case for uniform taxation. The important results of Goodfriend and King (2001) are also in the spirit of the recent New Keynesian literature emphasising the stabilisation of output around its flexible price level, instead of stabilisation of output *per se* (see, for example, Woodford (2002) and Gali (2001)). In this class of models there is no trade-off between price stability and the stability of the output gap. Price and output gap stability are complements.

Of course, both the uniform tax principle and the result on the complementarity of price and output gap stability only hold under very specific and stringent conditions, which are unlikely to hold empirically. However, as we will argue below in the context of cost-push shocks, these results are likely to hold as a good approximation under a much wider set of circumstances. For example, in the New-Keynesian set-up it is not clear that one would want monetary authorities to stabilise output around its flexible-price level if this output level is inefficiently low, for example because of monopolistic competition. However, from the analysis of the time-inconsistency problem by Kydland and Prescott (1977), Calvo (1978), and Barro and Gordon (1983a, 1983b), it is widely understood that the central bank's attempt to push output above its natural rate would be short-lived. After temporary effects working themselves through the economic system, the result would be no gain on the level of output front and permanently higher inflation. In other words, the attempt to stabilise output above its potential would lead to an *inflation level bias*.

In micro-founded models with monopolistic competitive firms and staggered price setting (like the NNS or New Keynesian models discussed above), the simplest way to induce a trade-off between price stability and output gap stability is by allowing for cost-push shocks. The idea is to allow potential output to vary in accordance to shocks to technology or preferences. In contrast, cost-push shocks would result from shocks to taxes, mark-ups or wages. The latter could derive, for example, from changes in the bargaining power of unions. Now, in our view, these cost-push raise a number of issues. First, as will be illustrated in Section 2, in the context of simple models the only difference between supply shocks and cost-push shocks is the way in which they enter the monetary authorities objective function. By convention a supply shock affects potential output, while a cost-push shock does not. The trade-off is therefore created by the assumed form of the authorities objective function and could easily be avoided by defining potential output as the flexible-price level of output. Second, it is an open issue what is the role of changes in taxation and in the bargaining power of unions to explain economic developments at business cycle frequency. For example, a permanent upward shift in unions' bargaining power would push up inflation and real wages. However permanently higher real wages would, all other things equal, lead to permanently lower equilibrium output. If this permanent level shift is not allowed to affect the central bank's target level of output, it leads to an *inflation level bias* as described above. These remarks lead to the intuition that it is worthwhile to examine these questions, when thinking about the design of the delegation contract for the central bank.

In the rest of this paper we will allow for temporary, but persistent cost-push shocks. Our aim is to show that, even forcing a trade-off between price stability and output gap stability, there are intrinsic difficulties associated with having the monetary authority stabilise output (and the output gap) in response to such shocks. These difficulties have to do with the endogeneity of private agents expectations. This endogeneity is, in turn, closely linked with the importance that central bankers attribute to credibility. In section 2, we discuss the well-known time-inconsistency problem associated with active output gap stabilisation. Following Clarida, Gali and Gertler (1999), we show that assigning monetary policy to a central bank that predominantly focuses on price stability can alleviate this problem. Section 3 analyses some of the problems associated with the substantial uncertainty that surrounds estimates of the appropriate target for output. Following Smets and Wouters (2002), we argue that focusing on price stability is a robust monetary policy strategy in the face of such uncertainty. Finally, in Section 4 we investigate the implications of the fact that the private sector is learning about the inflation process when forming its inflation expectations. Following the ideas of Orphanides and Williams (2002), we argue that also in this case, putting too much weight on output gap stabilisation in the central bank's mandate is counterproductive in the sense that it risks unhinging inflation expectations and thereby causing costly output gap fluctuations necessary to restore price stability. In order to illustrate the main arguments, in each these three Sections, we will use the same simple model economy developed by Woodford (2002) and Clarida, Gali and Gertler (1999). The concluding Section 5 presents the thrust of our main arguments, which can be summarised as follows: even in the presence of so-called cost-push shocks, a central bank predominantly focusing on price stability will contribute to the stability of the output gap. The reason is that by emphasising the single goal of price stability, the central bank anchors inflation expectations and thereby reduces on important source of instability in the economy that otherwise may give rise to an output gap inflation variability trade-off. The end result is an improved overall macro-economic performance.

2. Cost-push shocks, time-inconsistency and Rogoff's conservative central banker

In this Section, we briefly discuss the well-known time-inconsistency problem associated with active output gap stabilisation in the face of so-called cost-push shocks.[2] The economy is given by the following New-Keynesian Phillips curve:

(1) $$\pi_t = \beta E_t \pi_{t+1} + \kappa(y_t - \bar{y}_t) + u_t = \beta E_t \pi_{t+1} + \kappa z_t + u_t$$

where y_t denotes real output, $\bar{y}_t$ the potential output level which coincides with the central bank's target level of output, z_t the output gap, π_t the inflation rate, E_t the expectation operator based on information available at time t and u_t a cost-push shock variable that affects inflation, but does not affect the target level of output. For simplicity, we will assume that β, the discount factor, equals one. In the following, we will also assume that the cost-push shock variable follows an AR(1) process:

(2) $$u_t = \rho u_{t-1} + v_t$$

where v_t is a white noise stochastic process with variance σ_v^2. The stochastic process driving potential output can be more general, but does not need to be specified for our analysis.

As shown by Woodford (2002), equation (1) can be derived from the linearised version of a micro-founded model in which monopolistically competitive firms set their prices in a staggered way according to a Calvo (1983) scheme. In such a model, one can show that potential output will be driven by technology and preference shocks, whereas the cost-push shock may result from a time-varying mark-up in the goods or labour market or time-varying taxes on revenues in goods and labour markets.

Woodford (2002) also shows that in such a model a welfare-maximising central bank would like to stabilise a weighted average of deviations of inflation from the central bank's inflation target and output around its potential level . This objective function can be captured by the following quadratic loss function:

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[2] The analysis here partially follows Clarida, Gali and Gertler (1999), which should be consulted for a more thorough discussion of the time-consistency problem in the context of the model used in this paper.

(3) $$E_t \sum_{i=0}^{\infty} \beta^i ((\pi_{t+i} - \bar{\pi})^2 + \lambda (z_{t+i})^2),$$

where the weight λ on output gap stabilisation is determined by the underlying parameters of the model. For simplicity, we will assume that the central bank can control output and thus the output gap. In a more realistic model, the central bank would control output and inflation through the short-term interest rate. However, this simplification does not affect our main results.

Putting equations (1) and (3) together, it is clear that the only difference between the potential output (or supply) shocks and the cost-push shocks is that the former affect the central bank's target level of output, whereas the latter do not. The underlying (micro-founded) reason for the loss function (3) is that while it is optimal for a welfare-maximising central bank to accommodate shocks to supply that arise from changes in technology or preferences, it is not optimal to allow inefficient variations in output, for example, driven by temporary changes in taxes, mark-ups or the bargaining power of unions.

In this context, it is trivial to see that the supply shocks do not create a trade-off between output gap and inflation stabilisation. Stabilising the output gap in response to such shocks will also stabilise inflation. Or, put differently, stabilising inflation will also keep output close to potential. This is an example of the complementarity result discussed in the Introduction. In contrast, the cost-push shock will give rise to a trade-off between inflation and output gap stabilisation, if the output gap is defined as in equation (1). However, if the output gap were to be defined as the deviation of actual output from its flexible-price level, then again there would be no trade-off. Using the micro-foundations, it is easy to show that under flexible prices output will be determined by:

(4) $$y_t^n = \bar{y}_t - \frac{1}{\kappa} u_t$$

As a result, the flexible-price output gap is given by $z_t^n = y_t - y_t^n = y_t - \bar{y}_t + (1/\kappa)u_t = z_t + (1/\kappa)u_t$. Using this definition of the output gap in equation (3), it is again trivial to show there will be no trade-off between inflation and output gap stabilisation.

Turning again to model (1) to (3), it is straightforward to show that the optimal time-consistent monetary policy will be given by the following reaction function for the output gap:

(5) $$z_t = -\frac{\kappa}{\kappa^2 + \lambda}(E_t \pi_{t+1} - \bar{\pi} + u_t),$$

which, given equation (1), can also be written in the more standard form as:

(6) $$z_t = -\frac{\kappa}{\lambda}(\pi_t - \bar{\pi}) = -\alpha(\pi_t - \bar{\pi}).$$

Combining equations (1) and (6), the output gap and inflation can be written as a function of the cost-push shock and the inflation target, as follows:

(7) $$z_t = -\frac{\kappa}{\kappa^2 + \lambda(1-\rho)} u_t .$$

(8) $$\pi_t = \bar{\pi} + \frac{\lambda}{\kappa^2 + \lambda(1-\rho)} u_t$$

From equations (7) and (8), it is again clear that the cost-push shocks create a trade-off between output gap and inflation stabilisation. How much inflation volatility is allowed will depend on the weight on output gap stabilisation in the central bank's loss function. If this weight is zero, then inflation will always be equal to target in this model, but output gap volatility will be relatively large. A positive weight will reduce output gap variability, but increase inflation volatility. Varying the weight on output gap stabilisation gives rise to Taylor's famous inflation/output gap variability efficiency frontier, which is a crucial ingredient of much of the optimal policy literature (See, for example, Taylor, 1999).

From equation (8), it is also clear that as long as the cost-push shocks are stationary, there will be no systematic inflation bias. However, as shown by Clarida, Gali and Gertler (1999), the presence of a cost-push shock does imply that the optimal time-consistent policy suffers from a stabilisation bias: inflation volatility will be too large compared with the case in which the central bank can commit to its future policy actions and can thereby affect inflation expectations. In response to a persistent positive cost-push shock, the central bank would like to promise to contract output in the future in order to stabilise current inflation expectations and inflation, but the private agents realise that in the absence of a commitment device the central bank has an incentive to renege on that promise, once inflation expectations have adjusted. As a result, inflation expectations and inflation are temporarily too high in response to such a shock.

One solution, originally proposed by Rogoff (1985) to solve the time-inconsistency problem is to delegate monetary policy to a central banker that puts less weight on output gap stabilisation. In this simple set-up, the optimal degree of "conservativeness" can be calculated analytically by minimising the loss function (3) subject to equations (1), (2) and (6) with respect to the parameter α , which reflects the central bank's reaction coefficient to deviations of inflation from target and is a function of the central bank's weight on output gap stabilisation.[3] Doing this, one can show that the optimal reaction coefficient in equation (6) is given by:

(9) $$\alpha^* = \frac{\kappa}{\lambda(1-\rho)} = \frac{\alpha}{1-\rho}$$

From equation (9), it is clear that as long as the cost-push shock is persistent, it is optimal to increase the output response to deviations of inflation from target. Or, equivalently, it is optimal to reduce the central bank's weight on output gap stabilisation. How much this weight needs to be reduced depends on the degree of persistence of the cost-push shock. In the limit, if the shock has a unit root, the optimal mandate is to focus solely on inflation stabilisation. As one can argue that many of the cost-push shocks

[3] See Clarida, Gali and Gertler (1999).

that one typically has in mind such as changes in the bargaining power of unions or changes in taxes are likely to be very persistent, this analysis suggests that the dominant focus should be on price stability if central banks want to avoid excessive volatility in inflation and the output gap.

3. Potential output uncertainty and output gap stabilisation

The previous analysis was based on the assumption that both the central bank and the private sector know the level of potential output. In practice, there is a considerable degree of uncertainty about the appropriate target level of output. In this Section, we analyse how this uncertainty affects the central bank's optimal policy strategy and, in particular, the feasibility of stabilising the output gap. The question of optimal monetary policy under output gap uncertainty has recently received quite a bit of attention. For example, Orphanides (2000, 2001), analyses actual monetary policy-making by the Federal Reserve and shows that once one takes into account the real-time estimates of potential output, there is very little evidence of a big structural break in US monetary policy-making over the 1970s and 1980s. A Taylor-type rule seems to characterise policies quite well. What appears to be different in the 1970s versus the 1980s, is the degree of activism, i.e. the relative weight that is put on output gap versus inflation stabilisation. Orphanides argues that the unknown shocks to potential output together with the larger degree of activism in the 1970s is the dominant explanation for the big run-up in inflation in the 1970s. Orphanides (2001) shows that indeed a policy that does not take into account the destabilisation of the economy that results from mismeasurement of potential output can lead to an inefficient outcome. Using recent results by Svensson and Woodford (2000), Ehrmann and Smets (2002) show that society will indeed appoint a more conservative central banker when there is considerable uncertainty about potential output, even if the central bank applies optimal filtering techniques.

In this Section, we follow the analysis of Smets and Wouters (2002) by analysing robust monetary policy when the central bank does not know the source of unexpected inflation developments (supply or cost-push shocks) in the framework discussed above. In practice, both types of shocks are likely to drive inflation developments. It is, however, very difficult to distinguish between the two types. As is clear from equation (1), if the central bank only observes inflation and output, there is a fundamental identification problem. In reality, one may argue that central banks have additional information about the source of inflation developments. For example, oil price developments are a typical driving force of inflation. However, even in that case it is a non-trivial and very uncertain exercise to figure out what the supply effects are of such oil price shocks. In the rest of this Section we therefore ask the question: If the central bank has no information about whether the inflation shock affects potential output or not, what is the best minimax strategy, i.e. what assumption regarding the source of the shock and the associated policy response minimises the maximum loss. For this we calculate and compare the losses of these policies when the alternative assumption is the true one. For simplicity we assume in this section that the inflation target is zero.

As in the previous Section, we assume that the central bank can not commit to its future policy actions so that it takes inflation expectations as given. The optimal time-consistent policy is given by equations (7) and (8). If the shock is a supply shock, then the outcome for inflation and output is given by:

(10) $$y_t = -\frac{1}{\kappa} u_t = \bar{y}_t \,,$$

(11) $$\pi_t = 0 \,.$$

In this case the loss is minimised at zero:

(12) $$L_{SS} = 0 + 0$$

If the shock is a cost-push shock, then the outcome for inflation and output is given by:

(13) $$y_t = -\frac{\kappa}{\kappa^2 + \lambda(1 - \beta\rho)} u_t \,,$$

(14) $$\pi_t = \frac{\lambda}{\kappa^2 + \lambda(1 - \beta\rho)} u_t$$

In this case, the loss is given by:

(15) $$L_{CC} = \frac{1}{1 - \beta\rho^2} \left[\frac{\lambda^2}{q^2} + \lambda \frac{\kappa^2}{q^2} \right],$$

where $q = \kappa^2 + \lambda(1 - \beta\rho)$.

Next, we analyse what is the robust policy to follow when the central bank does not know which inflation shock affects the economy. We define a robust policy as that policy (or assumption about the source of the inflation shock) that minimises the loss in the case that the alternative assumption is the true one. Table 1 summarises the results.

The upper right cell of Table 1 shows that if the central bank assumes that the inflation shock is a supply shock when it is in fact a cost-push shock, then it will still stabilise inflation, but it will create output gap volatility by contracting output to achieve those stable prices. On the other hand, if the central bank assumes the shock is cost-push, when in fact it is a supply shock, then it will create both unnecessary output and inflation volatility (compared to the optimal outcome).

Under what policy is the loss associated with a mistake minimised? This can be seen by comparing the entries in the lower row of Table 1. It is easy to see that the maximum loss of assuming the shock is a supply shock is always less than or equal to the maximum loss of assuming the shock is a cost-push shock.

Table 1: Losses under alternative assumptions

	Shock is a supply shock	Shock is a cost-push shock
CB assumes a supply shock	$L_{SS} = 0 + 0$	$L_{CS} = \frac{1}{1-\beta\rho^2}\left[0 + \lambda \frac{1}{\kappa^2}\right]$
CB assumes a cost-push shock	$L_{SC} = \frac{1}{1-\beta\rho^2}\left[\frac{\lambda^2}{q^2} + \lambda\left(\frac{q-\kappa^2}{\kappa q}\right)^2\right]$	$L_{CC} = \frac{1}{1-\beta\rho^2}\left[\frac{\lambda^2}{q^2} + \lambda \frac{\kappa^2}{q^2}\right]$
Maximum loss (compared to the optimal)	$L_{SC} - L_{SS} = \frac{1}{1-\beta\rho^2}\frac{\lambda^2\left[\kappa^2 + \lambda(1-\beta\rho)^2\right]}{\kappa^2 q^2}$	$L_{CS} - L_{CC} = \frac{1}{1-\beta\rho^2}\left[\frac{\lambda^2\left[\kappa^2 + \lambda(1-\beta\rho)^2\right]}{\kappa^2 q^2} - \frac{2\lambda^2\beta\rho}{\left[\kappa^2 + \lambda(1-\beta\rho)\right]^2}\right]$

The difference between the two maximum losses is given by:

$$(16) \qquad (L_{CS} - L_{CC}) - (L_{SC} - L_{SS}) = -\frac{2\lambda^2\beta\rho}{\left(1-\beta\rho^2\right)\left[\kappa^2 + \lambda(1-\beta\rho)\right]^2}$$

The gain (in a minimax sense) from assuming that the shock is a supply shock (rather than a cost-push shock) is an increasing function of the persistence of the shock and the weight on output gap stabilisation. When the shock has no persistence ($\rho = 0$), the loss from making a mistake is equally great when assuming either a cost-push or a supply shock. However, as the persistence of the shocks increases assuming that the inflation shock is a supply shock becomes robust policy. The intuitive reason for this result is that assuming a shock is a supply shock will avoid negative effects on inflation expectations as inflation is expected to be stabilised even if in reality it is a cost-push shock. This is not the case when the opposite mistake is made. The negative impact on inflation expectations will be greater the more persistent the inflation shocks are.

Another interesting finding is that the larger the weight on output gap stabilisation the higher the relative benefits of assuming all shocks are supply shocks. Again, the intuition is that the effect of making mistakes on inflation expectations is greater with a high weight on output gap stabilisation and thus the cost of assuming that shocks are cost-push when they are in fact supply is much higher than that of making the reverse mistake.

4. Private sector learning and output gap stabilisation

In the previous Section, we analysed the effects of the central bank's uncertainty about what type of shock is hitting the economy and argued that, when in doubt, the robust strategy is for the central bank to treat shocks to inflation as supply shocks. This can be implemented by mandating the central bank to focus solely on inflation stabilisation. In this Section, we discuss some of the implications of uncertainty on the part of the private agents in the economy and emphasise the importance of giving clear signals to anchor inflation expectations when these are formed through a learning process. Also here there is a recent, but growing literature on how monetary policy should respond when the private sector is learning.[4] Following the analysis in Orphanides and Williams (2002), the main idea here is to see how the economy behaves under different weights on output gap stabilisation when the private sector is using a simple constant gain least squares regression model to learn about the inflation process and form its expectations. Our main finding is that with perpetual learning a large weight on output gap stabilisation risks unhinging inflation expectations when a series of cost-push shocks in the same direction hit the economy.

Taking again as a starting point the model of equation (1) and (2) and assuming that the central bank implements the reaction function given by equation (5), the law of motion of inflation is given by:

$$(17) \qquad \pi_t = (1-\gamma)\overline{\pi} + \gamma \tilde{E}_t \pi_{t+1} + \gamma u_t \ ,$$

where $\gamma = \dfrac{\lambda}{\kappa^2 + \lambda}$.

The tilde on the expectations operator denotes the fact that in this Section expectations may not be fully rational. It is worth noting that the weight on output gap stabilisation will determine to what extent the inflation process is anchored at the inflation target and to what extent it will be driven by inflation expectations itself. Thus, with zero weight on output gap stabilisation ($\gamma = 0$), inflation will only depend on the inflation target. In contrast, with very little weight on inflation stabilisation, there is a lot of scope for inflation expectations to move the actual inflation process.

As shown in equation (8), under rational expectations, the equilibrium solution for inflation is given by:

$$(18) \qquad \pi_t^{RE} = \overline{\pi} + \frac{\gamma}{1-\gamma\rho} u_t$$

Alternatively, the equilibrium solution for inflation under rational expectations can be written as the following first-order autoregressive process:

$$(19) \qquad \pi_t^{RE} = (1-\rho)\overline{\pi} + \rho \pi_{t-1}^{RE} + \frac{\gamma}{1-\gamma\rho} v_t$$

It is therefore not unreasonable, to assume that, as is common practice in the learning literature, private agents use an estimated first-order autoregressive process for inflation when forming their inflation expectations:[5]

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4 See, for example, Evans and Honkapohja (2002).

5 An important difference with most of the analysis in Evans and Honkapohja (2001) is that agents do not use the minimum-state-variable (MSV) equation (18) to form their expectations. If they did, it turns out that recursive least squares learning is e-stable, which under the assumptions of the model is always satisfied ($\beta\gamma < 1$). We also found that in this case constant-gain learning is very stable for reasonable estimation windows. Our assumption in (20) is a small and reasonable deviation from the MSV case, but turns out to have quite important implications for the overall stability of the system as illustrated by the simulations.

(20) $\pi_t = c_{0,t} + c_{1,t}\pi_{t-1} + \omega_t$

According to this regression model, expected future inflation is given by:

(21) $\widetilde{E}_t \pi_{t+1} = c_{0,t}(1 + c_{1,t}) + c_{1,t}^2 \pi_{t-1}$

where we have assumed that agents do not observe contemporaneous inflation in order to avoid the simultaneity problem which would arise from the fact that agents use current inflation to update their estimates and form their expectations which in turn affect current inflation leading to a revision in their updated parameter estimates and so on.

Under least squares learning, the private agents update the parameters of the perceived law of motion (20) according to the following equations:

(22) $c_t = c_{t-1} + \phi R_t^{-1} X_{t-1}(\pi_{t-1} - X'_{t-1}\, c_{t-1})$

(23) $R_t = R_{t-1} + \phi(X_{t-1}X'_{t-1} - R_{t-1})$,

where $X_t = [1 \quad \pi_{t-1}]'$ and $c_t = \lfloor c_{0,t} \quad c_{1,t} \rfloor$ and ϕ is a small positive constant Kalman gain, which is directly linked to the data sample, *l*, over which the regression is estimated: $\phi = 2/l$.

We can now analyse the behaviour of the economy under constant gain least squares learning by simulating equations (17), (21), (22) and (23) for a particular set of parameters under different assumptions regarding the weight on output gap stabilisation. Graph 1 reports the evolution of inflation, the output gap and the agents' estimated persistence of the inflation process for a particular realisation of the cost-push shock process. In this simulation we have assumed the following parameters: $\overline{\pi} = 1.5$, $\kappa = 0.2$, $\rho = 0.5$, $\sigma_v^2 = 0.2$ and $\phi = 0.05$ (implying an estimation window of 40 periods). As starting values for the estimated parameters in equation (20), we took the corresponding values of the rational expectations coefficients in equation (19). Graph 1 reports the outcomes for four different weights on output gap stabilisation: 0.0, 0.1, 0.5 and 1.0 assuming the same realisation of shocks. A number of observations are worth making. First, when the weight on output gap stabilisation is zero, inflation is perfectly stabilised and agents continuously use the "right" model to form their inflation expectations. However, output exhibits a relatively large short-term volatility reflecting the fact that it takes all the adjustment in response to the cost-push shocks. Second, as the weight on output gap stabilisation increases, the short-term volatility in the output gap falls, but the inflation process becomes more volatile. However, in contrast to the findings under rational expectations, also the persistence of the inflation and output gap process increases substantially. This reflects similar findings in Orphanides and Williams (2002). The average estimated degree of inflation persistence over the sample of 400 periods (as captured by the estimated autoregressive coefficient $c_{1,t}$) increases from 0.47 for a very small weight of 0.01 to 0.60, 0.73 and 0.80 for a weight on output gap stabilisation of 0.1, 0.5 and 1.0 respectively. Moreover, the bottom panel of Graph 1 shows that the estimated degree of persistence is quite variable over time depending on the particular realisation of the cost-push shocks. Finally, a run of subsequent positive cost-push shocks around period 220, sets inflation off on a inflationary spiral, which is clearly more pronounced the more weight the central bank puts on output gap stabilisation. With a high weight on output gap stabilisation, this episode is characterised by an estimated inflation persistence close to a unit root, suggesting that inflation expectations loose their nominal anchor. It is also noteworthy that this inflationary spiral is accompanied by a very persistent negative output gap and therefore can be characterised as a stagflationary episode similar to that experienced in the 1970s. While eventually the central bank's desire to stabilise inflation leads to a reversal of the inflationary spiral, the disinflation process is taking much longer than the inflationary phase. It is also worth noting that although such episodes do not appear in the particular simulation of Graph 1, also deflationary spirals can occur.

The large and persistent deviations of both inflation and the output gap from target when the central bank puts a lot of weight on output gap stabilisation, suggest that also in this case it may be beneficial to mandate the central bank to focus predominantly on price stability. In order to check this, we increased the simulation sample to 10000 periods and calculated the average loss using equal weights on inflation and output gap stabilisation when the central bank has a reduced weight on output gap stabilisation. Graph 2 presents the results for different estimation windows. First, it is clear that for reasonable estimation windows the optimal weight on output gap stabilisation is very low. For $\phi = 0.05$ (an estimation window of 40 periods), the optimal weight for the central bank is 0.15 compared to society's weight of 1. An important finding is that, in contrast to the time-inconsistency argument of Section 2, both inflation and output gap variability are substantially reduced by focusing predominantly on inflation stabilisation. The intuitive reason is that a focus on price stability anchors inflation expectations and reduces the risk that following a series of cost-push shocks in the same direction an inflationary spiral arises. Once they arise such spirals are also very costly in terms of output gap stabilisation as the central bank is trying to re-establish price stability. Second, as the private agents use more information (i.e. the estimation window lengthens), the optimal weight on output gap stabilisation increases.

5. Conclusions

In this paper we have challenged the widely held view that monetary authorities face a meaningful trade-off between stabilising inflation and stabilising the output gap. In our view price stability and output gap stability should be seen as complements. This is a point of significant practical importance for the conduct of monetary policy.

In this paper we allow for cost-push shocks that create a trade-off between price stability and output gap stability. Even in this case it is still a good idea to focus, first and foremost, on price stability. The reason for this is linked to the endogeneity of inflation expectations. The emphasis on price stability helps to anchor inflation expectations leading to superior outcomes in terms of overall macroeconomic stability.

We started by reviewing the well-known time-inconsistency problem. When the central bank is bound to follow time-consistent policies, output gap stabilisation leads to a stabilisation bias associated with inefficiently high inflation variability. Increasing the relative weight on inflation stabilisation improves the resulting equilibrium. Secondly, we discussed a simple case where the central bank does not know whether it is facing a supply shock or a cost-push shock. These shocks are postulated to be observationally equivalent. For such a case we show that focus on price stability leads to robust policy.

Finally, we considered the case where private agents are trying to estimate the inflation generating process using an “ad hoc”, but reasonable learning rule. By emphasising a single goal the central bank facilitates the process of learning thereby improving results in terms of both inflation stability and output gap stability. Interestingly with sufficiently high weight on output gap stabilisation it is possible to obtain paths for inflation and the output gap characterised by the simultaneous occurrence of persistent high inflation and output below potential. This resembles the stagflation experience of the 1970s.

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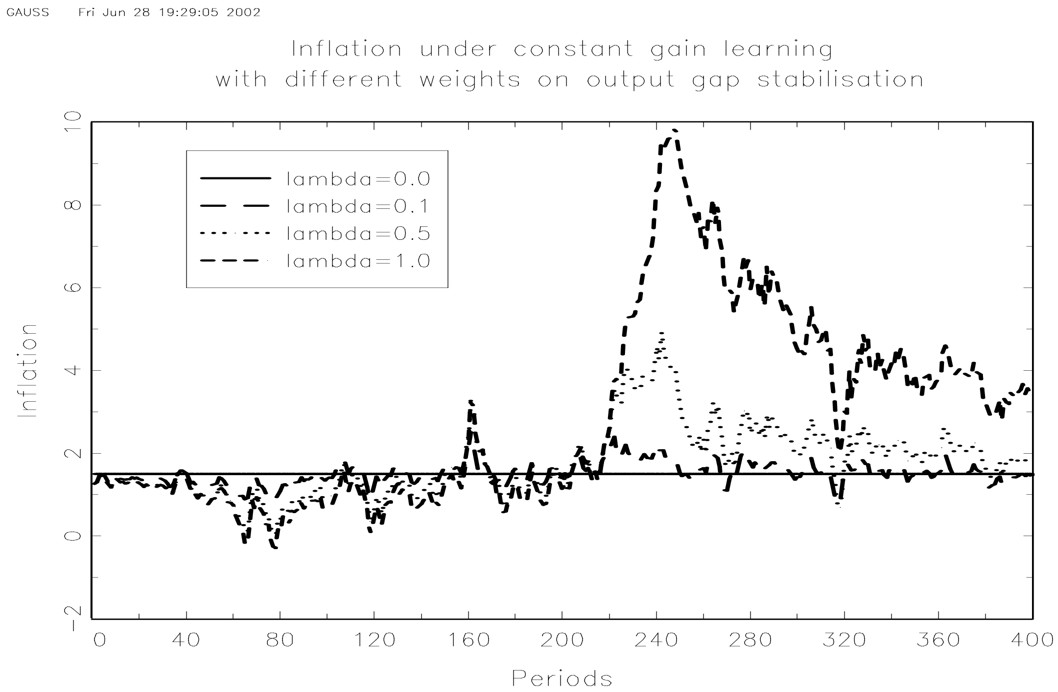
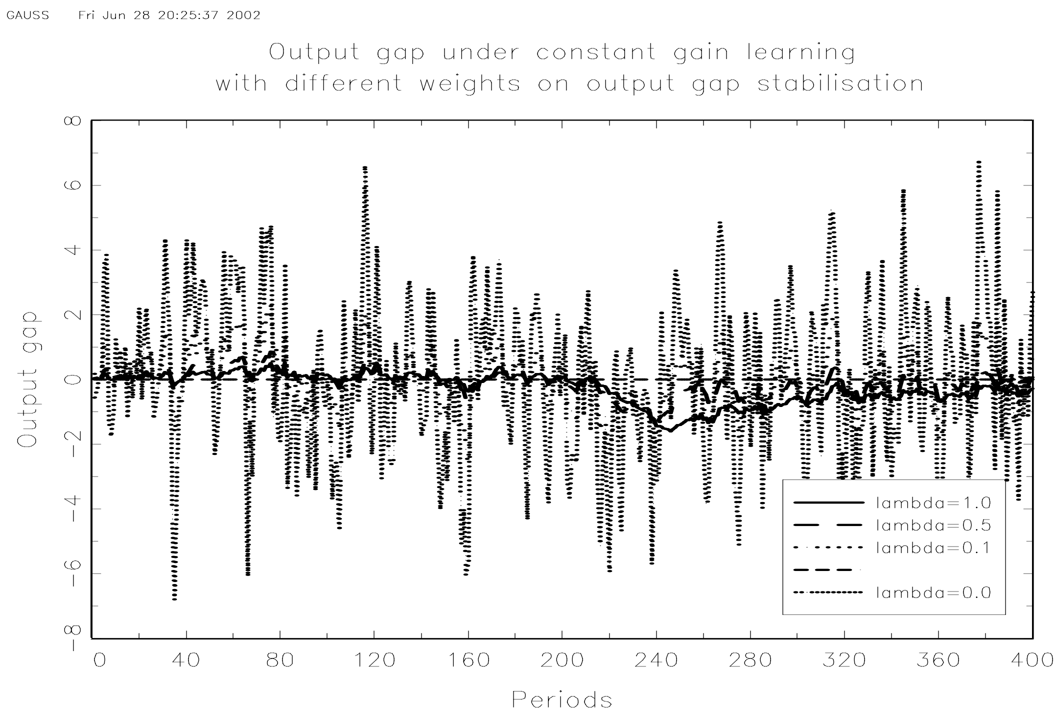
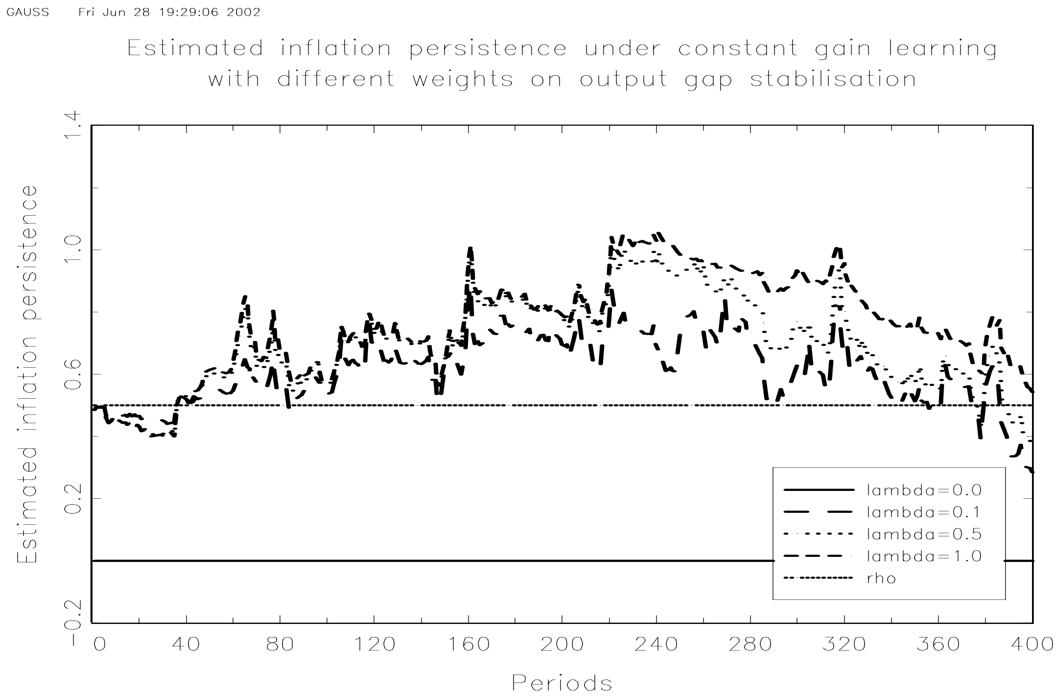
Graph 1a



Graph 1b



Graph 1c



Graph 2